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(*)
FINAL REPORT

An Ecological and Taxonomic Survey of the
Freshwater Algae of Petroleum Reserve No. 4,
in Relation to Distribution of Arctic and
Alpine Algae in the Western Hemisphere

The field work for this project was carried on during the late summer and fall of 1951, the summer, fall and winter of 1952, the summer of 1953 (all in arctic Alaska, Arctic Research Laboratory); also (by extension of contract) in the spring of 1953 (January-April) in the alpine regions of Ecuador. The writer wishes to express his appreciation and gratitude to the Office of Naval Research, the personnel of the Arctic Research Laboratory Advisory Board, and to the Director and staff of the Arctic Research Laboratory for making this investigation possible.

The personnel in this project consisted of: G. W. Prescott, investigator; Mr. George Lauff, Mr. William Vinyard (assistants, 1951); Mr. Robert Haubrich, Mr. John Koranda (assistants, 1952-1953).

The stated objectives of this survey are:

- 1.) To learn what are the species of aquatic plants (algae and flowering plants which exist in western arctic North America.
- 2.) To relate the flora of the western arctic to that reported from

(*) A more detailed report will be prepared and scientific papers will be written after laboratory examinations and analyses have been completed. This phase of the work, of necessity, has to be extended. This present report is submitted as a final report on operation under the contract.

the eastern arctic (especially the flora of Greenland and north Asia) in order to determine possible patterns of circumpolar distribution.

3.) To compare (and contrast) the arctic aquatic flora with that of alpine situations, especially in relation to glaciation.

4.) To relate the flora of arctic and alpine environments to limnological and other ecological factors in respective habitats whereby explanations of distribution, or at least significant correlations might develop.

5.) To determine the quantity and quality of the aquatic flora in the above mentioned regions in reference to the suitableness of bodies of water for the stocking of fish.

Biological Collections

In 1951 about 400 qualitative collections of algae were made and preserved for subsequent study from miscellaneous habitats, mostly within a 15-mile radius of Point Barrow, Alaska. Through the kindness of cooperative colleagues, a number of collections were obtained from the regions around Umiat and Fairbanks, Alaska. Also, from selected lakes, a series of quantitative samples were taken for a limnological study of bodies of water in the Alaskan arctic. Because of the time factor and conditions limiting field work, the 1951 operation was defined as exploratory.

In 1952 collections began in June and ended in December. Early in this period and toward the latter part, borings were made through ice (up to 9 feet thick) in order to obtain biological and limnological samples. Because of the constancy of the character of samples taken through the ice after the onset of winter, it was deemed to be not feasible to continue the survey beyond mid-winter. In addition to collections from strictly aquatic habitats, subaerial habitats also were sampled, and a large collection of lichens was taken for a study of the unknown algal components of these organisms in the arctic.

Higher aquatic plants were collected and preserved for identification in order to make correlations with the algal flora and the ecology of the respective habitats.

In January-April (by extension of the project to include alpine studies) 600 or more collections of algae (and higher aquatic plants) were made in the Andes Mountains in Ecuador.

In the summer of 1953 a few additional qualitative and quantitative algal collections were made from Petroleum Reserve No. 4 for comparison with the collections from the same habitats in previous summers.

These collections are all housed in the writer's private herbarium at Michigan State College. Some duplicates have been distributed and others will be prepared for distribution to such herbaria as may be designated by ONR.

Chemical Data

In order to relate aquatic organisms with ecological factors, water samples were taken and analyzed in the laboratory. Readings included: pH, dissolved oxygen; alkalinity; hardness, calcium, iron, nitrogen, and phosphorus. These analyses were made on samples from six selected lakes upon which an intensive study was directed, but pH and alkalinity readings were made from practically all habitats sampled, both in the arctic and in the Andes. In the latter area, hardness of water (grains per gallon) was also determined.

Physical Data

Water and air temperatures were recorded. Also the biota of solidly frozen lakes and ponds was examined for a study of the ability of organisms to exist in a frozen condition. The local U. S. Weather Bureau at Point Barrow kindly furnished daily light-duration and light-intensity (calories per sq. cm.) readings with which plant periodicity and population densities are being related. These data, physical, chemical, and population densities, are being plotted on

graphs with the objective of showing correlations and possible explanations of distribution of plants both in time and in space.

Studies at Home Laboratory

Quantitative samples have been examined and analyzed (counts made). Qualitative samples (numbering about 1600) are in the process of being examined. All species are being illustrated as part of a plan to publish on the aquatic flora of Petroleum Reserve No. 4. New species are being described as they appear in the collections.

For the taxonomic and identification work, and in order to meet some of the objectives of the project, considerable library work is being required and it has been necessary to obtain some literature not immediately available. A tedious but highly essential check list of arctic and alpine species as reported in the literature is being compiled.

Tentative Summary

General Nature of Lakes in Petroleum Reserve No. 4

The majority of the lakes examined are shallow (averaging about 15 feet for maximum depth), and accordingly most of them freeze to the bottom (the first ice forming about the middle of September). In area the six lakes selected for study vary from about 100 acres to some which are over a mile in length by half a mile wide.

Whereas the temperature of the water may be as high as 7.5 deg. C. in midsummer it was found to be 0.9-2.0 deg. C. most of the time during which the study was being carried on. There is an average difference of 0.5 deg. C. between the bottom and surface water during the summer period.

Because of the constancy of precipitation (however slight) and of seepage from the melting of frozen tundra, the water level of the lakes fluctuates insignificantly. During midsummer there is considerable erosion on almost all shores because of the persistent strong winds which whip up a strong wave action.

The winds are variable in direction (at least in the Barrow region) so that erosion occurs about equally on all shores. Even so, erosion is relatively slight on these tundra lakes because of the compactness of the marginal plant cover and accordingly the lake shores are even and the lakes are circular in general outline, or oval. In most instances where the shore line is not even it is because the arctic grass, Arctophyla fulva has migrated into the water and has built up points and shoals.

The lakes, in general, are slightly basic, some having a pH as high as 7.8. The same lake may vary in this respect from 6.8 to 7.6 throughout the summer, possibly because of the difference in photosynthetic activity and the uptake of CO_2 . The lakes are low in electrolytes and the usual attending plant nutrients. Especially they are low in nitrogen and phosphorus. Hence plant life in the larger bodies of water is poorly represented, some being almost 'deserts' with only a few species of diatoms (low in numbers) being the only photosynthetic organisms found. Attached and filamentous algae in nearly all lakes were the kinds that are usually found in hard water habitats in lower latitudes (Rhizoclonium, Vaucheria, Spirogyra, Scytonema, Oscillatoria).

Most of the small lakes and ponds in the tundra are basic also, but in general, supported a greater variety of plant life (both flowering plants and algae). When compared with ponds and pools in lower latitudes, however, they are poor producers, both in respect to quantity and variety of species. One alga, Botryococcus braunii was the only one which in its development approached a 'bloom' condition.

In contrast, many small tundra pools, ditches, and swales were usually found to be acid (pH 6.0-6.9), although some were neutral (pH 7.0). Slightly basic tundra pools were found to have a Diatom-Cyanophyta type of algal flora and to support a red 'strain' of the grass, Arctophyla fulva; whereas the acid pond had a Desmid-Chlorophyta type of algal flora and supported a green-gray 'strain' of the grass.

of the grass. In the more highly acid pools and ditches where there was a zoogloea of bacteria and fungi there was a relatively abundant and varied algal population. Invariably such habitats were those in or near erosion areas and where there had been a break-down of the tundra mat with attendant decomposition by bacteria and fungi of the organic matter in tundra soil. Thus there seems to be a definite relationship between bacterial decomposition and a varied algal flora, the more or less obvious explanation being that in such habitats there is a greater amount of dissolved nutrients.

In spite of the fact that the base soil formations throughout the tundra seemed to be similar, and although ecological conditions in general are similar there was found to be great variation in the lakes, both in respect to their chemistry and the composition of the flora. Detailed soil maps of the area are not available, but studies in progress are going to show, apparently, that significant differences in soil chemistry and physics exist.

Figures will be presented in detailed reports to show the variability in alkalinity, hardness, calcium-content, etc. The arctic slope in Alaska is unique because of the fact that it lies in an unglaciated area. This means that the habitats and the biota of the region have been unmodified by the attending disturbances of glaciation and one is permitted to suppose that the flora and fauna (both terrestrial and aquatic) might show unique features also.

In at least three of the lakes studied intensively (Imerksungk, Ikrowik, Imikpuk) the flora and microfauna were found to be sufficient in quantity to support a limited fish population. In only one (Ikrowik) are fish known to occur. From our present knowledge it would appear to be expedient to stock with fish those lakes which are able to support a food chain, providing, of course, that those lakes were deep enough as to not freeze solid during the winter.

ALPINE COLLECTIONS

In Ecuador three months were spent in high altitudes (9,500-14,500 feet). Collections were made from thirty high altitude lakes in 5 different provinces of the country, in addition to collections from numerous ponds, streams, bogs and marshes; also subaerial habitats. For comparison one series of collections was made down to an elevation of 1300 feet on the Amazon side of the Andes. Also a few collections were made from near sea level on the Pacific lowlands to the west of the mountains.

Besides algae, associated higher plants were also collected, as well as terrestrial plants in the vicinity of alpine lakes and bogs. Temperature, pH and hardness (grains per gallon) readings were taken.

Truly alpine lakes showed floral characteristics usually possessed by snow-fed bodies of water, namely: an almost total absence of species. Those which did occur, however, are considered to be of significance and the composition of these floras will be compared with those of other high altitudes and with lists of arctic plants when analyses of the samples have been completed. Although but few of the samples have been examined, there appears at present to be some interesting similarities between alpine and arctic algal floras.

In general, alpine lakes are low in nutrients (as would be expected), and are neutral or slightly basic. Hence they cannot support a rich biota. Hanging bogs at high altitudes also were found to be 'desertous'. As in arctic situations, however, where there was bacterial decomposition and an erosion of the top soil there was a corresponding increase in the amount and in the kinds of algae. This was striking in some situations where a small pool in a bog contained a rich zooplaea of algae (principally desmids) lying but a few feet from other habitats in which there were no algae at all.

Crater lakes, theoretically suitable for algal floras in some respects, were found to have scanty growths (but unique in composition). Nearly always such lakes possessed a Diatom-Cyano phyta-Chara flora.

In subalpine lakes which had been influenced by human settlements, there were relatively rich floras of both aquatic flowering plants and algae. This is in keeping with the greater amounts of dissolved nitrogen and phosphorus. The lake which was the richest, perhaps, of any examined in respect to both bulk and quality of algae was Laguna Yarquacochi (Lake of Blood). This lake apparently shows still the effects of the increased nitrogen provided it when 10,000 slaughtered Indian warriors were thrown into it during the time of the Incas.

A paper reporting on this investigation was presented at the Alaska Science Conference (AAAS) meeting at McKinley Park in September, 1952. Also a paper was presented at the Michigan Academy of Science, meeting in Ann Arbor, March, 1954. In October, 1953 a preliminary report was published in the American Midland Naturalist, 50(2): 463-473, entitled: Preliminary Notes on the Ecology of Freshwater Algae of the Arctic Slope, Alaska, with Descriptions of some New Species.

G. T. Prescott